METHOD AND SYSTEM FOR CONTROLLING A HOUSEHOLD WATER SUPPLY INCORPORATING MOTION-SENSING FOR DETERMINING WHETHER A HOUSE IS OCCUPIED

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a Continuation-in-Part of U.S. patent application no. 10/122,880 entitled "METHOD AND SYSTEM FOR CONTROLLING A HOUSEHOLD WATER SUPPLY" filed on April 11th, 2002, the specification of which is herein incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to water control systems, and more specifically, to a system for controlling a household water supply.

2. Background of the Invention

Water supplies connected to a household are typically controlled only at the points of service, e.g., sink faucets, shower valves and appliances that connect to the water supply provide individual shut-off for water flow. The household water supply connection is typically controlled by a manual external valve that can be used to shut-off water flow in the event of an

emergency water leak or for servicing the water supply system plumbing or replacing appliances.

Flooding due to plumbing failures is a major source of damage to structures and fixtures such as carpeting, wood flooring, wallboard, etc. The most frequent water supply emergency events are failure due to freezing temperatures inside the water supply plumbing and failure of the water heater tank. A freezing condition usually occurs when the house is unoccupied, for example, a vacation home that is unoccupied during winter is at risk for damage due to bursting of water supply lines due to freezing. Other water supply emergency events may occur when the house is unoccupied, such as failure of a polyvinyl chloride (PVC) plumbing joint, or water heater tank wall erosion and leakage.

Since water pressure needs to be available while persons are present in the household, the supply pressure must be available when the household is occupied. Also, certain automatic water users such as icemakers, dishwashers and washing machines make automatic demands on the water supply that may occur when the household is unoccupied. It is also inconvenient to manually control a household water supply upon entering or exiting a household.

Systems have been implemented that shut off the household water supply in response to detection of leaks using detectors located near water heaters, sinks, etc. But, these systems only protect against leaks where water reaches the detectors and could require a large number of detectors for adequate coverage. Other systems have been developed that measure water flow and shut off the water supply if excessive flow occurs based on whether or not the house is occupied as programmed manually by a switch. The flow type systems typically use flow meters that are incapable of detecting water flows below a certain threshold, such as a dripping faucet.

Therefore, it would be desirable to provide a method and system for controlling a household water supply to prevent flooding. It would further be desirable to control a household water supply in a manner that automatic water users are able to obtain water for a limited time, while preventing leaks that occur while the water supply is not being used.

SUMMARY OF THE INVENTION

The above objective of preventing flooding due to plumbing failure is achieved in a method and system that automatically control a water supply for an entire house or branches thereof feeding multiple water receiving appliances or fixtures. The system includes an electrically controllable valve, a motion sensor and a control system for controlling the automatic valve in conformity with a motion detector output. The motion sensor has a detection range that extends substantially beyond the vicinity of a single appliance or fixture, so that motion in the household in general is detectable in order to determine whether or not the household is occupied. A timer may be used to determine whether motion has not occurred for a long period of time, and if so, the automatic valve is shut off. Various alarms may be used in conjunction in the above system, such as thermal and seismic alarms that immediately shut off the water

The foregoing and other objectives, features, and advantages of the invention will be apparent from the following, more particular, description of the preferred embodiment of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram depicting a household water supply coupled to a system in accordance with an embodiment of the present invention.

Figure 2 is a block diagram depicting a system in accordance with an embodiment of the present invention.

Figure 3 is a pictorial diagram depicting control panel **34** of **Figure 2.**

Figure 4 is a flowchart depicting operation a system in accordance with an embodiment of the present invention.

Figure 5 is a flowchart depicting further operation of a system in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The above-incorporated parent patent application discloses and claims a method and system for controlling a household water supply in conformity with a detected flow and a motion sensor that determines whether or not there is activity within a household. The present continuation-in-part concerns particular embodiments of the previously-disclosed system that do not require flow detection, thus providing water control to a household at reduced cost. The motion detectors of the present invention have a detection range that encompasses an area significantly greater than the local around a specific water fixture or water-supplied appliance, distinguishing the operation of the present invention from such fixtures as faucets and toilets that are operated based on motion detection for use in public facilities.

Motion sensors are located within the household or at particular locations such as entrances, so that occupancy of the house may be determined via detection of motion of a person or persons and an electrically controllable valve can shut off branch plumbing lines to the entire house, or sections thereof that connect to multiple water fixtures.

Referring now to the figures and in particular to **Figure 1**, a household water supply coupled to a system in accordance with an embodiment of the present invention is shown. Within household **10**, a cold water supply line **11** routes the water supply to various fixtures such as sinks **14**, a refrigerator **16** containing an ice maker **17** toilets **15**, and so forth. A water heater **12** is also coupled to cold water supply line **11**, to supply a hot water supply line **13**, which is routed to sinks **14** and other fixtures in household **10**. Hot water supply line is shown optionally controlled by an electrically controllable valve **21A**, to illustrate a branch plumbing line that feeds multiple fixtures that is controlled by feedback from a motion sensing system. Cold water supply line **11** is also coupled to lawn sprinklers **18** by electrically controlled sprinkler valves **19** that are activated and deactivated by an electric sprinkler control **20** system.

Water pressure for the entire household **10** water supply system is provided by a water supply main coupling controlled by electrically controllable valve **21**. (Alternatively a portion of the household water supply may be controlled via valve **21A** and multiple valves may be used to control such a system, which is particularly useful in such structures as duplexes.) A control system **30** in accordance with an embodiment of the present

invention is electrically coupled to electrically controlled valve **21**, to shut off the water supply to household **10** in the presence of a detected abnormal flow condition. Flow of water into household **10** may be detected by flow meter **24** which is generally a positive flow meter as described in co-pending U.S. Patent Application entitled: "POSITIVE FLOW METER", Ser. NO. 10/122,877 filed on April 11, 2002, the specification of which is incorporated herein by reference. However, a flow meter is not required for operation of the present invention, as the control of the household water supply or a plumbing branch feeding multiple water supplying fixtures may be based entirely on detected occupancy of the household.

However, use of a valve in accordance with the embodiment described in the above-referenced patent application permits the detection of very small flow rates associated with small leaks. As the present invention detects a leak in accordance with starting and stopping of water flow, a valve that can measure a very small continuous flow is exceptionally useful in embodiments of the present invention.

Within household **10**, are located motion sensors **22**, providing an indication of occupancy of household, and consequently, whether water may be in normal use by an occupant

of household **10**. A motion sensor **22** may also be located near an entrance **23** in addition to or in alternative to locating motion sensors **22** throughout household **10**. If motion sensors **22** are located adjacent to every used entrance **23** of household **23**, occupancy may be determined, but generally not activity of occupants. If motion sensors **22** are located throughout household **10**, the system of the present invention may control water flow in accordance with activity of occupants by shutting off various branch plumbing lines.

Control system **30** derives information from motion sensors **22** and (optionally flow meter **24**) in order to control the household **10** water supply via electrically controllable valve **21**. Information from other sensors for detecting abnormal conditions may also be provided to control system **30** as well as manual controls and operating controls. Sprinkler control **20** is electrically coupled to control system **30** to provide a signal of normal sprinkler usage.

Referring now to **Figure 2**, details of control circuit **30** and its interconnections are depicted. Control circuit **30** receives motion sensor inputs and sprinkler control inputs, as well as an input from a seismic activity detector **31**, a temperature detector **32** and a control panel **34**. Temperature

detector **32** is used to predict potentially freezing conditions within cold water supply line **11** and electrically controllable valve **21** may be shut off in conformity with detecting the potentially freezing condition. Likewise, seismic activity detector **31** provides an indication of earthquake activity, and electrically controllable valve **21** may be shut off in conformity with detecting an earthquake. Temperature detector **32** and seismic activity detector **31** may be switches activated upon detection of the associated event, or they may be sensors and the detection circuitry may be provided within control circuit **30**.

Control panel **34** provides for manual control of control circuit (and thus the system of the present invention) via controls **36** and provides an indication of operational state via visual indicators **35** and a beeper **37** for providing an audible alarm. Remote control and indication of state may be provided by a modem/network interface **33** which may be coupled to a telephone network or other suitable network connection such as Digital Subscriber Link (DSL), cable modem or a router connection deriving therefrom. Control operations may be performed within control circuit **30** in response to codes received by modem/network interface **33** and system status may be provided by

control circuit **30** to a remote location via modem/network interface **33**.

Within control circuit **30**, control is provided by program code executed from memory **42** by a processor **41**. Memory **42** and processor **41** are provided by a programmable logic controller **40**, although other forms of processing system such as single board computers, may be used to implement control algorithms in accordance with the present invention and dedicated circuits may also be used. A particular advantage of programmable logic controller **40** is that remote control modules such as X10 controllers are commercially available to couple control circuit **30** to various sensors, e.g. packaged motion sensors are available with X10 connections that transmit signals via household **10** power lines, making it unnecessary to directly wire motion sensors to control circuit **30**. Additionally, controls are available so that electrically controllable valve could be operated by an X10 controller. However, particular advantages associated with a manual override within the present invention might make remote control of electrically controllable valve **21** undesirable.

Programmable logic controller **40** controls electrically controllable valve **21** via relay **K1**. A manual override timer **43**

provides a timeout when a system user operates a manual "on" control from control panel **34**. Relay **K2** is activated when the manual "on" control is pressed, turning on electrically controllable valve **21** until the timeout occurs (generally one hour). The system uses a battery **38** to supply operating power for control circuit **30**, but the manual override may be used in event of failure of portions of the system or loss of the programmable logic controller **40** control program. Loss of household **10** primary power may also affect portions of the system, depending on implementation, so manual override timer **43** may also be useful during a power failure. A battery charging and sensing circuit **39** connects to battery **38** from control circuit **30**. Battery **38** is maintained in a charged state by charging and sensing circuit **39**, and automatic operation of the system may be held off while battery **38** has insufficient charge to properly operate the system.

Since battery power should be conserved by the system, electrically controllable valve **21** is preferably a pulse type valve (latching solenoid valve). Therefore, programmable logic controller **40** or manual override timer **43** activate electrically controllable valve **21** using a pulse (generally on the order of 0.5 second) to either turn on or turn off electrically controllable valve. Special circuits within control circuit **30**

may be used to produce the pulses, or programmable logic controller **40** may be programmed to produce the desired pulse. Manual override timer **43** will generally comprise a one-shot pulse generator that generates a pulse to turn off electrically controllable valve **21** after the timeout has occurred.

Referring now to **Figure 3**, details of control panel **34** are depicted. Controls are provided as follows: Reset switch **36A** provides a means to reset programmable logic controller **40** and other circuits within control circuit **30**; water on switch **36B** provides one hour of manual override water flow via manual override timer **43**; water off switch turns of water flow **36C**; and learn mode switch **36D** activates a learn mode of operation. Indicators **35** are provided on control panel **34** and may also be located remotely. A monitor indicator notifies a user that the system is actively monitoring the house for motion indicating occupancy; an away indicator indicates that lack of motion sensor activity has caused the system to enter "away" mode. A seismic alarm, low temp alarm and water flow alarm indicator are used to indicate earthquake detect, freezing detect or leak detect, respectively. A buzzer **37** is integrated within control panel **34** to provide an audible alarm, generally in accordance with a logical-OR combination of the above alarm indications.

Learn mode operation in the context of the present invention refers to the determination of motion in a household. The present invention uses a "long" cycle to control operation of electrically controllable valve **21**. Essentially, a timer is reset at each detected movement within the household or controlled area of a structure and a period of time of water supply operation is permitted before the water is shut off. This permits appliances such as washing machines and dishwashers to complete their cycles when set by an occupant who then leaves the household. A long cycle is the time period that water is permitted to flow when no motion sensors have detected activity recently within household **10**. The long cycle is adjustable, depending on the programmable logic controller program. Code within the programmable logic controller program measures typical motion detection of occupants of the household. The typical use is turned into operational variables to control the long cycle and motion detection sensitivity, generally the long cycle will be within the range of 1/2 to 2 hours and the motion detection algorithm will require several events before determining that the household is occupied. The programmable logic controller program permits setting of the long cycle via the front panel and also learns sensitivity for the motion detection when learn mode is selected. Learn mode is generally self-terminated after, for example a 24 hour period.

Referring now to **Figure 4**, operation of a system in accordance with an embodiment of the present invention is depicted. First, a battery-charging loop is activated (**step 60**) that controls charging of battery **38**, so that operation may be initiated only after battery **38** has sufficient charge to operate the system. The battery voltage is sampled and when the battery voltage is sufficient (**decision 61**), the motion sense flow control program is started (**step 62**). During operation, a manual override switch may interrupt operation (**decision 63**) to pulse the valve control circuit (**step 64**) to provide or stop water flow. If water on switch **36B** was pressed (i.e. the water is on) (**decision 65**) then the manual override timer **66** provides the timeout that pulses valve control (**step 64**) to shut off the valve.

Referring now to **Figure 5**, further operation of a system in accordance with an embodiment of the invention is depicted. **Figure 5** illustrates the automatic operation of the motion sense control program activated in **step 62** of **Figure 4**. Motion detectors are monitored and if no motion is detected for a long period (**decision 70**) and the water supply is on (**decision 71**), the valve is pulsed off (**step 72**). If motion is detected (**decision 73**) and the water is off (**decision 74**), the valve is pulsed on (**step 75**), corresponding to detection of occupancy and

the long period is reset (**step 76**). If motion is detected from a motion sensor (**decision 72**) and the water is currently turned off (**decision 73**) the water is turned on (**step 74**). If an alarm indication is received from sensors, such as thermal or seismic detectors (**decision 77**), the water is shut off (**step 78**) and an alarm indication is sent (**step 79**) which may be a visual indication via indicator **35**, an audible alarm via buzzer **37**, a remote message via modem/network interface **33**, or a combination of the above.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form, and details may be made therein without departing from the spirit and scope of the invention.